The present invention relates to fibers having an increased surface roughness. Further, the present invention relates to nonwovens, laminates and composites comprising such fibers. Additionally, the present invention relates to a process for producing such fibers, nonwovens, laminates and composites.
FIBERS AND NONWOVENS WITH INCREASED SURFACE ROUGHNESS

FIELD OF THE INVENTION

[0001] The present invention relates to fibers having an increased surface roughness. Further, the present invention relates to nonwovens, laminates and composites comprising such fibers. Additionally, the present invention relates to a process for producing such fibers, nonwovens, laminates and composites.

THE TECHNICAL PROBLEM AND THE PRIOR ART

[0002] Polypropylene fibers are used in a wide range of applications, ranging from construction and agricultural industries over hygiene products, such as baby diapers, feminine hygiene products, adult incontinence products, or wipes, to medical applications, such as medical drapes and surgical gowns. In most of these applications polypropylene fibers are not used as such but rather in the form of nonwovens, which can be produced for example by thermal bonding of staple fibers, the spunbonding process, the melt blown process, or the spunlacing (hydroentanglement) process.

[0003] In order to be suitable for a specific application, the polypropylene therefore does not only need to have certain properties, such as mechanical properties, but also be adapted to a specific nonwoven-forming process. This is frequently done by applying spin finishes to the fibers either during or after their production. Alternatively, this can be done by blending the polypropylene with additives so that the additives are incorporated into the polypropylene and then migrate to the surface to give the desired functionality to the fiber.

[0004] A particular example of a transformation process that requires a spin finish is the spunlacing (hydroentanglement) process. In spunlacing polypropylene fibers are randomly distributed to form a nonconsolidated web, which is then consolidated using fine high-pressure water jets. Due to the action of the water jets a high percentage of the spin finish is lost to the process water, from which it then needs to be removed again for environmental reasons.

[0005] Further to adapting fibers for specific transformation processes, spin finishes are used to impart certain functionalities to the polypropylene fibers, for instance hydrophilicity. Known polypropylene fibers have a smooth surface, and therefore do not easily retain spin finishes. Thus, much more spin finish than would be required to obtain the desired level of functionality needs to be applied.

[0006] In addition, and this is also the case for additives blended into the polypropylene, the functionality level that can be attained is limited by the surface area of the fibers. Thus, an increase in the fiber surface area would also allow an increased level of functionalities, such as hydrophilicity.

[0007] EP-A-0607476 discloses a polymeric strand including a blend of a melt-extrudable polyolefin and a heterophasic polypropylene composition. Preferably, the heterophasic polypropylene composition is present in up to 40 wt%. Fabric made with such blends is disclosed to have improved combinations of strength, abrasion resistance and softness properties. This document further discloses that the heterophasic polypropylene composition by itself is not melt-spinable.

[0008] WO 2007/071496 discloses soft filaments and nonwovens obtained therefrom, said filaments comprising a blend of 55-95 wt% of a propylene copolymer and 5-55 wt% of a heterophasic propylene polymer composition.

[0009] U.S. Pat. No. 5,900,306 discloses nonwoven fabric, particularly spunbond nonwoven fabric, produced with a blend including a heterophasic polymer in an amount up to 50 wt%.

[0010] EP-A-1452630 discloses fibers comprising a heterophasic propylene copolymer containing a) a matrix phase comprising a propylene random copolymer, and b) a disperse phase comprising an ethylene rubber copolymer. The fibers are characterized by excellent softness.

[0011] However, all of these documents disclose that the use of a heterophasic propylene copolymer results in soft fibers and nonwovens. None of them discloses how to increase the surface area of the fibers.

[0012] Thus, there is a need in the industry for polypropylene fibers, i.e. fibers comprising a polypropylene, that have improved retention of spin finishes.

[0013] There is also a need in the industry to provide polypropylene fibers with increased surface area.

[0014] Further, there is also a need in the industry to provide polypropylene fibers with an increased level of functionality.

[0015] Hence, it is an object of the present invention to provide polypropylene fibers having an increased surface roughness.

[0016] Additionally, it is an object of the present invention to provide polypropylene fibers and nonwovens that can be produced easily.

[0017] It is a further object of the present invention to provide polypropylene fibers and nonwovens that have good properties, in particular good mechanical properties.

[0018] It is another object of the present invention to provide polypropylene fibers and nonwovens having an increased level of functionality, such as for example hydrophilicity.

[0019] Furthermore, it is an object of the present invention to provide polypropylene fibers that are better suited to some transformation process, in particular to the spunlacing process.

[0020] It is an even further object of the present invention to provide fibers having an increased bulkiness.

BRIEF DESCRIPTION OF THE INVENTION

[0021] We have now discovered that at least one of the above objectives can be met with the fibers of the present invention.

[0022] Thus, the present invention provides a multicomponent fiber comprising an interior component and an exterior component, wherein said exterior component covers at least 50% of the surface of said fiber and comprises at least 70 wt% of a heterophasic propylene copolymer relative to the total weight of the exterior component, said heterophasic propylene copolymer comprising a propylene polymer matrix and a rubber.

[0023] In addition, the present invention provides nonwovens, laminates and composites comprising such fibers.

[0024] Further, the present invention provides a process for the production of such fibers, said process comprising the steps of

[0025] (a) providing a thermoplastic polymer to a first extruder,

[0026] (b) providing a polymer blend to a second extruder,
(c) melt-extruding the thermoplastic polymer of step (a) through a number of fine, usually circular, capillaries of a spinneret,

(d) melt-extruding the polymer blend of step (b) through a number of fine openings surrounding said capillaries of step (c), and

(e) combining the extrudates of steps (c) and (d) to form single fibers of an intermediate diameter, such that the extrudate of step (d) forms an exterior component covering at least 50% of the surface of the fiber produced by combining the extrudates, wherein the polymer blend of step (b) comprises at least 70 wt % of a heterophasic propylene, said heterophasic propylene copolymer comprising a propylene polymer matrix and a rubber.

Furthermore, the present invention discloses the use of a heterophasic propylene copolymer in the exterior component of a multifilament fiber, said multifilament fiber comprising an interior component and an exterior component, to increase the surface roughness of said multifilament fiber in comparison to the surface roughness of a fiber comprising an exterior component, said exterior component covering the entire surface of the fiber and consisting of a propylene homopolymer.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**FIG. 1** is a scanning electron microscope picture of the surface of bicomponent spunbond fibers with a heterophasic propylene copolymer as exterior component.

**FIG. 2** is a scanning electron microscope picture of the surface of monocomponent spunbond fibers made with a propylene homopolymer grade.

**DETAILED DESCRIPTION OF THE INVENTION**

For the purpose of the present invention, the terms “fiber” and “filament” are used interchangeably.

The present invention provides a multifilament fiber that comprises an interior component and an exterior component, wherein said exterior component covers at least 50% of the surface of said multifilament fiber, and wherein said exterior component comprises at least 70 wt % of a heterophasic propylene copolymer relative to the total weight of said exterior component.

Preferably, said exterior component covers at least 70% of the surface of said multifilament fiber, more preferably at least 90%, even more preferably at least 95%, still even more preferably at least 99% and most preferably it covers the entire surface of the fiber.

Preferably, said exterior component comprises at least 80 wt %, more preferably at least 90 wt %, even more preferably at least 95 wt %, 97 wt % or 99 wt % relative to the total weight of the exterior component, and most preferably said exterior component consists of a heterophasic propylene copolymer. In addition to the heterophasic propylene copolymer the exterior component may comprise additives or thermoplastic polymers that are miscible with the heterophasic propylene copolymer, such as for example propylene homopolymer or propylene random copolymer.

The polymer that is used in the interior component is not especially limited. It is, however, preferred that it is a thermoplastic polymer, more preferred that it is polyolefin, and most preferred that it is a polypropylene.

Other thermoplastic polymers that are suited for use in the present invention can be selected from the group consisting of polyethylene, polyamide, polyester and polycarbonate. All of these are for example described in Stockchert, Kunststoff Lexikon, W. Weebeken (ed.), 9th edition, Carl Hansen Verlag, München, Wien, 1998 or in Römp Chemie Lexikon, J. Falbe and M. Regitz (eds.), 9th edition, Georg Thieme Verlag, Stuttgart, New York 1995.

The heterophasic propylene copolymer used in the present invention comprises a propylene polymer matrix and a rubber. Because the propylene polymer matrix and the rubber are immiscible, the heterophasic propylene copolymer used in the present invention is characterized by at least two distinct phases, with rubber particles dispersed within the propylene polymer matrix.

The heterophasic propylene copolymer has a melt flow index in the range from 5 dg/min to 2000 dg/min as measured according to ISO 1133, condition L, at 230°C and 2.16 kg. When used for fiber spinning, for example for the production of staple fibers, the melt flow index of the heterophasic propylene copolymer is in the range from 5 dg/min to 40 dg/min. When used in the spunbonding process the melt flow index of the heterophasic propylene copolymer is at least 10 dg/min, preferably at least 15 dg/min, and most preferably at least 20 dg/min. When used in the spunbonding process the melt flow index of the heterophasic propylene copolymer is at most 300 dg/min, preferably at most 200 dg/min, more preferably at most 150 dg/min, even more preferably at most 100 dg/min, and most preferably at most 60 dg/min. When used in the melt blown process the melt flow index of the heterophasic propylene copolymer is at least 100 dg/min, preferably at least 150 dg/min, more preferably at least 200 dg/min, even more preferably at least 250 dg/min, and most preferably at least 300 dg/min.

When used in the melt blown process the melt flow index of the heterophasic propylene copolymer is at most 2000 dg/min, preferably at most 1800 dg/min or 1600 dg/min, even more preferably at most 1400 dg/min or 1200 dg/min, and most preferably at most 1000 dg/min.

Preferably, the heterophasic propylene copolymer used in the present invention has a molecular weight distribution $M_w/M_n$ of at least 3.5, more preferably of at least 4.0, even more preferably of at least 4.1, 4.2, 4.3 or 4.4, and most preferably of at least 4.5. Preferably, the molecular weight distribution $M_w/M_n$ is at most 8.0, more preferably at most 7.5 or 7.0, even more preferably at most 6.5 and most preferably at most 6.0. The molecular weights and the molecular weight distribution can be determined by size exclusion chromatography (SEC) as described in more detail in the examples.

When the molecular weight distribution $M_w/M_n$ of the heterophasic propylene copolymer is too broad, such as is generally the case for polypropylene obtained with a Ziegler-Natta catalyst, it may be narrowed by chemical or thermal degradation from a starting melt flow index $MFI_1$ to a final melt flow index $MFI_2$ (measured according to ISO 1133, condition L, 230°C, 2.16 kg). Chemical degradation (visbreaking) is preferred. For chemical degradation of the propylene polymer is brought into intimate contact with a peroxide (e.g. 2,5-dimethylhexane-2,5-di-tertbutylperoxide) at an elevated temperature, thus leading to the generation of radicals which in turn lead to a breakdown of the polymer chains. In consequence, the melt flow index of the propylene polymer increases. Without wishing to be bound by theory, it is thought that the radicals preferentially attack the longer polymer chains for statistical reasons; the molecular weight dis-
Visbreaking of propylene polymers is usually carried out at temperatures in the range from 200° C. to 250° C. It can for example be done in the extruder in the granulation step of a propylene polymer manufacturing plant.

[0043] Preferably, the propylene polymer matrix of the heterophasic propylene copolymers of the present invention comprises a propylene homopolymer or a random copolymer of propylene and at least one further olefin different from propylene.

[0044] In case of a random copolymer said further olefin is preferably present in up to 4.0 wt% relative to the total weight of the random copolymer. More preferably it is present in up to 3.5 wt%, 3.0 wt%, or 2.0 wt%, even more preferably in up to 1.5 wt%, still even more preferably in up to 1.0 wt% and most preferably in up to 0.5 wt% relative to the total weight of the random copolymer. Said further olefin is an α-olefin. It may for example be ethylene, 1-butene, 1-pentene, 4-methyl-1-pentene, 1-hexene, or 1-octene, of which ethylene and 1-butene are preferred, with ethylene being the most preferred.

[0045] Preferably the melting temperature is at least 150° C., more preferably at least 155° C. and most preferably at least 160° C. Without wishing to be bound by theory it is believed that a melting temperature of at least 150° C. improves the processability of the heterophasic propylene copolymer in fiber production. Melting temperatures can be determined by differential scanning calorimetry (DSC) according to ISO 3166. Generally, in order to erase the thermal history of the samples, they are first heated to a temperature above the melting temperature, e.g. to 200° C., and kept there for a certain time, e.g. for 3 minutes. After cooling the samples are then reheated for the measurement of the melting temperature. For the determination of the melting temperature the heating and cooling rate is 20° C/min.

[0046] The preferred propylene polymer matrix is a propylene homopolymer.

[0047] It is preferred that the propylene polymer matrix has a tacticity of more than 95.0% of mmnn pentads. The percentage of mmnn pentads is determined on the insoluble heptane fraction of the xylene soluble fraction according to the method described by G. J. Ray et al. in Macromolecules, vol. 10, no 4, 1977, p. 773-778). More preferably the tacticity is more than 96.0%, even more preferably more than 97.0%, and most preferably more than 98.0%. In other words, it is preferred that the propylene polymer matrix is comprised of a propylene polymer that is predominantly isotactic.

[0048] If the propylene polymer matrix is a propylene homopolymer it is preferred that its xylene soluble content is at most 2.5 wt% and most preferably at most 2.0 wt%, relative to the total weight of the propylene homopolymer. The xylene soluble content is determined by dissolving the polypropylene in refluxing xylene, cooling the solution to 25° C., filtering the solution, and subsequent evaporation of the solvent. The residue, which is the xylene soluble portion of the polypropylene, is then dried and weighed.

[0049] The rubber of the heterophasic propylene copolymer of the present invention comprises a first olefin, which is different from propylene, and a second olefin, which is different from the first olefin. Preferably, said first and second olefin are independently selected from the group consisting of ethylene and α-olefins. Specific examples for α-olefins that may be used are ethylene, propylene, 1-butene, 1-pentene, 4-methyl-1-pentene, 1-hexene, and 1-octene. As first olefin ethylene and butene are more preferred, with ethylene being most preferred. It is most preferred that the second olefin is propylene. Thus, the most preferred rubber is an ethylene-propylene rubber (EPR).

[0050] It is preferred that the first olefin is present in an amount of from 2.0 wt% to 20.0 wt% relative to the total weight of the heterophasic propylene copolymer, more preferably from 4.0 wt% to 16.0 wt%, even more preferably from 5.0 wt% to 15.0 wt% and most preferably from 7.0 wt% to 13.0 wt%. The total comonomer content can be determined for example by IR- or NMR-analysis, for example according to the method described by G. J. Ray et al. in Macromolecules, vol. 10, no 4, 1977, p. 773-778.

[0051] For the present invention it is preferred that the rubber is present in an amount from 8.0 wt% to 24.0 wt%, more preferably from 10.0 wt% to 22.0 wt%, and most preferably from 14.0 wt% to 18.0 wt% relative to the total weight of the heterophasic propylene copolymer. The amount of rubber is determined as the acetone insoluble fraction of the xylene soluble fraction. The acetone insoluble fraction of the xylene soluble fraction is obtained by dissolving the heterophasic propylene copolymer in refluxing xylene, cooling the solution to 25° C., filtering the solution, and subsequently agitating the solution together with acetone, which results in forming a precipitate. Said precipitate, which represents the acetone insoluble fraction of the xylene soluble fraction of the heterophasic propylene copolymer, is collected on a filter, dried and weighed.

[0052] Preferably, the propylene polymer matrix and the rubber, when taken together, comprise at least 90.0 wt% of the heterophasic propylene copolymer. More preferably, they comprise at least 95.0 wt% or 97.0 wt% or 99.0 wt%, and most preferably at least 99.5 wt% of the heterophasic propylene copolymer, and most preferably the heterophasic propylene copolymer consists of the propylene polymer matrix and the rubber.

[0053] Very surprisingly, it has been found that the bicomponent fibers of the present invention are characterized by an increased surface roughness as compared to conventional polypropylene fibers made with for example a propylene homopolymer. A comparison is shown in FIG. 1 and FIG. 2. FIG. 1 shows bicomponent fibers according to the present invention, i.e. having an exterior component comprising a heterophasic propylene copolymer, FIG. 2 shows fibers made from a propylene homopolymer. It can be clearly seen that the bicomponent fibers of FIG. 1 have increased surface roughness and also an increased surface area. In view of the documents cited earlier in this application, which disclose fibers comprising a heterophasic propylene copolymer as being characterized by increased softness, the rougher fiber surface was not at all expected by the present inventors.

[0054] Thus, the present invention also discloses the use of a heterophasic propylene copolymer to increase the surface roughness of a fiber. Preferably the present invention is directed to the use of a heterophasic propylene copolymer in the exterior component of a multicomponent fiber, said multicomponent fiber comprising an interior component and an exterior component, to increase the surface roughness of said multicomponent fiber in comparison to the surface roughness of a fiber comprising an exterior component, said exterior component covering the entire surface of the fiber and consisting of a propylene homopolymer. Most preferably, the present invention is directed to the use of a heterophasic propylene copolymer in the exterior component of a multicomponent fiber, said multicomponent fiber comprising an
interior component and an exterior component, wherein said exterior component covers at least 50% of the surface of said fiber and comprises at least 70 wt % of said heterophase propylene copolymer relative to the total weight of the exterior component, said heterophase propylene copolymer comprising a propylene polymer matrix and a rubber, to increase the surface roughness of said multicomponent fiber in comparison to the surface roughness of a fiber comprising an exterior component, said exterior component covering the entire surface of the fiber and consisting of a propylene homopolymer.

[0055] It can be estimated that at least 5% of the surface area of a multicomponent fiber comprising an exterior component entirely covering the surface of said bicomponent fiber, said exterior component consisting of a heterophase propylene copolymer, protrudes, thus causing the roughness of the fiber. By protruding it is meant, that the diameter of said multicomponent fiber at a protruding point is more than the diameter of a comparative fiber comprising an exterior component, said exterior component covering the entire surface of the comparative fiber and consisting of a propylene homopolymer, under the condition that both, the said bicomponent fiber as well as the said comparative fiber, have substantially the same denier and have been produced by the same production process. It goes without saying that the difference in diameters between said multicomponent fiber and said comparative fiber needs to be more than the error of measurement of the method used to determine the diameter. Fiber diameters can for example be determined from scanning electron microscope pictures.

[0056] Though the sizes of the protruding surface parts are very small in comparison to the fiber diameter it has been surprisingly found that such a small difference is already sufficient in reducing the layer-to-layer slipping of such fibers. This means that the nonwoven comprising such fibers will have improved properties as compared to a nonwoven made with polypropylene fibers having a smooth surface.

[0057] The heterophase propylene copolymers used in the present invention may also comprise additives, such as for example antioxidants, light stabilizers, acid scavengers, lubricants, antistatic agents, fillers, nucleating agents, clarifying agents, colorants. An overview of useful additives is given in Plastics Additives Handbook, ed. H. Zweifel, 5th edition, Hanser Publishers.

[0058] The heterophase propylene copolymers used in the present invention are produced either by physical or chemical blending. In physical blending a propylene polymer matrix and a rubber, which have been produced independently from one another, are blended together, for example in an extruder. In chemical blending, which is the preferred method, the propylene polymer matrix and the rubber are produced sequentially in at least two polymerization reactors in presence of a polymerization catalyst, usually a Ziegler-Natta or a metalloocene-based polymerization catalyst, with Ziegler-Natta polymerization catalysts being preferred. Typically, the rubber is produced in a gas-phase polymerization reactor. These production methods are well known to the person skilled in the art and need not be described in more detail.

[0059] The fiber of the present invention is a multicomponent fiber. Preferably it is a bicomponent fiber. Bi- or multi-component fibers or filaments are known in many different configurations, such as for example side-by-side, sheath-core, islands-in-the-sea, pie or stripe configurations. Bi- or multi-component fibers can be formed by co-extrusion of at least two different components into one fiber or filament. This is done by feeding the different components to a corresponding number of extruders and combining the different melts into a single fiber. The resulting fiber or filament has at least two different essentially continuous polymer phases. Such fibers or filaments, their production as well as their forming a nonwoven are well known to the skilled person and are for example described in F. Fourné, Synthetische Fasern, Carl Hanser Verlag, 1995, chapter 5.2 or in B. C. Goswami et al., Textile Yarns, John Wiley & Sons, 1977, p. 371-376.

[0060] Generally fibers are produced by melting the polymer in an extruder, optionally passing the molten polymer through a melt pump to ensure a constant feeding rate and then extruding the molten polymer through a number of fine capillaries of a spinneret to form fibers. These still molten fibers are simultaneously cooled by air, drawn to an intermediate diameter and collected. They are for example collected on a winder or other suitable collecting means.

[0061] Thus, the process for the production of the multicomponent fibers of the present invention comprises the steps of

(a) providing a thermoplastic polymer to a first extruder,
(b) providing a polymer blend to a second extruder,
(c) melt-extruding the thermoplastic polymer of step (a) through a number of fine, usually circular, capillaries of a spinneret,
(d) melt-extruding the polymer blend of step (b) through a number of fine openings surrounding said capillaries of step (c), and
(e) combining the extrudates of steps (c) and (d) to form single fibers of an intermediate diameter, such that the extrudate of step (d) forms an exterior component covering at least 50% of the surface of the fiber produced by combining the extrudates, wherein the polymer blend of step (b) comprises at least 70 wt % of a heterophase propylene copolymer as defined above.

[0062] Preferably the extrudate of step (d) forms an exterior component covering at least 70%, more preferably at least 90%, even more preferably at least 95% or 99% of the surface of the fiber, and most preferably it covers the entire surface of the fiber.

[0063] Preferably, said exterior component comprises at least 80 wt %, more preferably at least 90 wt %, even more preferably at least 95 wt %, 97 wt % or 99 wt % and most preferably consists of a heterophase propylene copolymer. In addition to the heterophase propylene copolymer the exterior component may comprise additives or thermoplastic polymers that are miscible with the heterophase propylene copolymer, such as for example propylene homopolymer or propylene random copolymer.

[0064] Optionally, the single filaments of an intermediate diameter, which are obtained in step (e) may be drawn to a final diameter, i.e. the process for the production of the multicomponent fibers of the present invention further comprises the step of

(f) rapidly reducing the intermediate diameter of the fibers obtained in step (e) to a final diameter.

[0065] The nonwovens of the present invention may be produced by any suitable method. Such methods include thermal bonding of staple fibers, the spunlacing process, the spunbonding process and the melt blown process. The preferred methods are the spunlacing process, the spunbonding
process and the melt blown process. Of these the spunlacing process and the spunbonding process are the more preferred ones, and the spunlacing process is the most preferred one.

[0072] For the production of nonwovens comprising the bicomponent fibers of the present invention the process further comprises the steps of

[0073] (g) collecting the fibers obtained in step (e) or step (f) on a support, and

[0074] (h) subsequently bonding the collected fibers to form a bonded nonwoven.

[0075] For the production of thermally bonded nonwovens the bicomponent fibers of the present invention are cut into staple fibers having a length in the range from 5 to 30 mm. Said staple fibers are then carded, i.e. collected as a more or less continuous non-consolidated web on a support. In a final step the non-consolidated web is consolidated by thermal or chemical bonding, with thermal bonding being preferred.

[0076] In the spunlacing process continuous fibers or staple fibers are distributed randomly a support to form a non-consolidated web, which is then consolidated by means of high-pressure water jets and dried.

[0077] In the spunbonding process a thermoplastic polymer is melted in a first extruder, optionally passed through a melt pump to ensure a constant feeding rate and then extruded through a number of fine, usually circular capillaries of a spinneret. In parallel a polymer blend comprising at least 70 wt% of a heteroplastic propylene copolymer as defined above is melted in a second extruder, optionally passed through a melt pump and then extruded through a number of fine openings surrounding the fine, usually circular capillaries of the spinneret. The extrudates of the molten thermoplastic polymer and the molten polymer blend are combined to form a single—essentially still molten—filament of an intermediate diameter. The filament formation can either be done by using one single spinneret with a large number of holes, generally several thousand, or by using several smaller spinnerets with a correspondingly lower number of holes per spinneret. After exiting from the spinneret, the still molten filaments are quenched by a current of air. The diameter of the filaments is then quickly reduced by a flow of high-pressure air. Air velocities in this drawdown step can range up to several thousand meters per minute. After drawdown the filaments are collected on a support, for example a forming wire or a porous forming belt, thus first forming an unbonded web, which is then passed through compaction rolls and finally through a bonding step. Bonding of the fabric may be accomplished by thermobonding, hydroentanglement, needle punching, or chemical bonding.

[0078] In the melt blown process a thermoplastic polymer is melted in a first extruder, optionally passed through a melt pump to ensure a constant feeding rate and then extruded through a number of fine, usually circular capillaries of a special melt blowing die. In parallel a polymer blend comprising at least 70 wt% of a heteroplastic propylene copolymer as defined above is melted in a second extruder, optionally passed through a melt pump and then extruded through a number of fine openings surrounding the fine, usually circular capillaries of the special melt blowing die. The extrudates of the molten thermoplastic polymer and the molten polymer blend are combined to form a single—essentially still molten—filament of an intermediate diameter. Usually melt blown dies have a single line of capillaries through which the molten polymer passes. After exiting from the die, the still molten filaments are contacted with hot air at high speed, which rapidly draws the fibers and, in combination with cool air, solidifies the filaments. In the following, the nonwoven is formed by depositing the filaments directly onto a forming wire or a porous forming belt.

[0079] Composites may be formed from two or more nonwovens, of which at least one is made in accordance with the present invention. Said two or more nonwovens may either be bonded together, or they may be left “unbonded” to one another, i.e. just placed on top of each other. In particular, the composites comprise a spunlace or spunbond nonwoven layer (S) according to the present invention or a melt blown nonwoven layer (M) according to the present invention. Composites in accordance with the present invention can for example be SS, SSS, SMS, SMMSS or any other combination of spunlace or spunbond and melt blown nonwoven layers.

[0080] The advantages of the increased surface roughness are particularly noticed in composites comprising the bicomponent fibers of the present invention because the nonwoven layers have a reduced tendency to displacement against one another. Hence, the overall mechanical properties of such a composite are improved.

[0081] A first nonwoven or composite, said first nonwoven or composite being in accordance with the present invention, and a film may be combined to form a laminate. The film preferably is a polyolefin film. The laminate is formed by bringing the first nonwoven or composite and the film together and laminating them to one another for example by passing them through a pair of lamination rolls. The laminates may further include a second nonwoven or composite, which can be but need not be according to the present invention, on the face of the film opposite to that of the first nonwoven or composite. In a preferred embodiment, the film of the laminate is a breathable polyolefin film, thus resulting in a laminate with breathable properties.

[0082] Thus, the laminates may be formed by laminating a film to the bonded nonwoven obtained in step (h). A composite may be formed by applying a nonwoven to the bonded nonwoven obtained in step (h).

[0083] The polypropylene fibers and filaments of the present invention can be used in carpets, woven textiles, and nonwovens.

[0084] The polypropylene spunbond nonwovens of the present invention as well as composites or laminates comprising it can be used for hygiene and sanitary products, such as for example diapers, feminine hygiene products and incontinence products, products for construction and agricultural applications, medical drapes and gowns, protective wear, lab coats, wipes, for example in sanitary but also in industrial applications, etc.

[0085] The polypropylene meltblown nonwovens of the present invention can be used in hygiene, filtration and absorption applications, such as diapers, feminine hygiene products, incontinence products, wraps, gowns, masks, filters, absorption pads etc. Frequently polypropylene meltblown nonwovens are used in combination with other nonwovens, such as for example spunbond nonwoven to form composites, which in turn may be used in the cited applications.

EXAMPLES

[0086] The melt flow index was measured according to ISO 1133, condition L, at 230°C and 2.16 kg.

[0087] Molecular weights are determined by Size Exclusion Chromatography (SEC) at high temperature (145°C). A
10 mg PP sample is dissolved at 160°C in 10 ml of TCB (technical grade) for 1 hour. The analytical conditions for the Alliance GPCV 2000 from Waters are:

- Volume: 400 μl
- Injector temperature: 140°C
- Column and detector: 145°C
- Column set: 2 Shodex AT-806MS and 1 Styragel HT6E

Flow rate 1 ml/min
Detector: Refractive index
Calibration: Narrow standards of polystyrene
Calculation: Based on Mark-Houwink relation

Melting temperatures T_m were measured on a DSC 2600 instrument by TA Instruments according to ISO 3146. To erase the thermal history the samples were first heated to 200°C and kept at 200°C for a period of 3 minutes. The reported melting temperatures were then determined with heating and cooling rates of 20°C/min.

Fiber titer was measured on a Zweigle viroscope S151/2 in accordance with norm ISO 1973:1995.

Tensile strength and elongation of the nonwovens were measured according to ISO 9073-3:1989.

**Base Materials**

Fibers and nonwovens were produced using a commercial polypropylene homopolymer spunbond grade, denoted as PP1, and a heteropropylene propylene copolymer, denoted as PP2.

PP2 had a propylene homopolymer as matrix and an ethylene-propylene rubber dispersed therein, with the rubber being present in 19.5 wt %, relative to the total weight of PP2. Total ethylene content of PP2 was 10.8 wt %, which was chemically degraded such that it had a final melt flow index (MFI) of 28 kg/min and a molecular weight distribution M_w/M_n of 4.7. The properties of PP1 and PP2 are shown in Table 1.

<p>| TABLE 1 |</p>
<table>
<thead>
<tr>
<th>PP1</th>
<th>PP2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFI</td>
<td>25</td>
</tr>
<tr>
<td>M_n</td>
<td>46</td>
</tr>
<tr>
<td>M_w</td>
<td>189</td>
</tr>
<tr>
<td>M_w / M_n</td>
<td>452 / 674</td>
</tr>
<tr>
<td>MWD = M_w / M_n</td>
<td>4.1 / 4.7</td>
</tr>
<tr>
<td>T_m</td>
<td>163</td>
</tr>
</tbody>
</table>

**Spunbond Nonwoven**

Polypropylenes PP1 and PP2 were used to produce the following spunbond nonwovens

**Example 1**

Bicomponent Nonwoven with PP1 as Interior Component and PP2 as Exterior Component wherein the Exterior Layer Comprised 30 wt % of the Total Weight of the Fibers

Comparative Example 1

Nonwoven Made from PP1

The spunbond nonwovens were produced on a 1.1 m wide Reicofil 4 line with a single beam having about 6800 holes per meter length, the holes having a diameter of 0.6 mm.

The nonwoven had a fabric weight of 12 g/m². The nonwoven were thermally bonded using an embossed roll. Further processing conditions are given in Table 2. The bonding roll temperature reported in Table 2 is the bonding temperature at which the highest values for elongation were obtained. Properties of the nonwovens obtained under these conditions are shown in Table 3.

**TABLE 2**

<p>| TABLE 2 |</p>
<table>
<thead>
<tr>
<th>Ex. 1</th>
<th>Comp. Ex. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belt speed</td>
<td>m/min</td>
</tr>
<tr>
<td>Throughput</td>
<td>Kg/h</td>
</tr>
<tr>
<td>Melt temperature at the die</td>
<td>°C</td>
</tr>
<tr>
<td>Exterior component</td>
<td>°C</td>
</tr>
<tr>
<td>Interior component</td>
<td>°C</td>
</tr>
<tr>
<td>Cabin pressure</td>
<td>Pa</td>
</tr>
<tr>
<td>Nip pressure</td>
<td>N/mm²</td>
</tr>
<tr>
<td>Calender temperature (set point) for max. elongation</td>
<td>°C</td>
</tr>
</tbody>
</table>

**TABLE 3**

<p>| TABLE 3 |</p>
<table>
<thead>
<tr>
<th>Ex. 1</th>
<th>Comp. Ex. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament titer</td>
<td>den</td>
</tr>
<tr>
<td>Tensile strength @ max MD</td>
<td>N/m</td>
</tr>
<tr>
<td>Tensile strength @ max CD</td>
<td>N/m</td>
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<tr>
<td>Elongation MD</td>
<td>%</td>
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<tr>
<td>Elongation CD</td>
<td>%</td>
</tr>
</tbody>
</table>

The results obtained on the spunbond nonwovens of example 1 and comparative example 1 show that the nonwovens made in accordance with the present invention are characterized by acceptable tensile strengths in both machine and cross-machine direction, and also have elongational properties in machine and cross-machine direction that are comparable to the ones obtained with a commercial propylene homopolymer spunbond grade.

**FIG. 1 and FIG. 2 show a scanning electron microscope picture of the fibers of example 1 and comparative example 1. In FIG. 2 it can be seen that the monocomponent fibers of comparative example 1 have a very smooth surface, which does not well hold on to any additives or spin finishes. By contrast FIG. 1 shows the bicomponent fibers of example 1, i.e. in accordance with the present invention. It can be seen that the heteropropylene propylene copolymer, which forms the exterior component, gives rise to a very rough surface, which allows better retention of any additive or spin finish.**

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of functionality-imparting molecules to be present on the fiber surface, thus rendering the fiber for example more hydrophilic.

[0107] Due to the increased surface roughness and the protruding elements the bicomponent fibers of the present invention are also expected to increase the fiber bulkiness, which is of advantage for bulk continuous filaments (BCF).

1. Multicomponent fiber comprising an interior component and an exterior component, wherein said exterior component covers at least 50% of the surface of said fiber and comprises at least 70 wt % of a heterophase propylene copolymer relative to the total weight of the exterior component, said heterophase propylene copolymer comprising a propylene polymer matrix and a rubber.

2. Multicomponent fiber according to claim 1, wherein the heterophase propylene copolymer comprises a propylene polymer matrix and a rubber, said rubber comprising a first olefin, which is different from propylene, and a second olefin, which is different from the first olefin, said first olefin being present in an amount of from 2.0 wt % to 20.0 wt % relative to the total weight of the heterophase propylene copolymer.

3. Multicomponent fiber according to claim 1, wherein the heterophase propylene copolymer is an ethylene-propylene rubber.

4. Multicomponent fiber according to claim 1, wherein the rubber is present in an amount from 8.0 wt % to 24.0 wt % relative to the total weight of the heterophase propylene copolymer.

5. Nonwoven comprising the multicomponent fibers of to claim 1.

6. Laminate or composite comprising the multicomponent fibers of claim 1.

7. Process for the production of the multicomponent fiber of claim 1, comprising the steps of
   (a) providing a thermoplastic polymer to a first extruder,
   (b) providing a polymer blend to a second extruder,
   (c) melt-extruding the thermoplastic polymer of step (a) through a number of fine, usually circular, capillaries of a spinneret,
   (d) melt-extruding the polymer blend of step (b) through a number of fine openings surrounding said capillaries of step (c), and
   (e) combining the extrudates of steps (c) and (d) to form single fibers of an intermediate diameter, such that the extrudate of step (d) forms an exterior component covering at least 50% of the surface of the fiber produced by combining the extrudates,
   wherein the polymer blend of step (b) comprises at least 70 wt % of a heterophase propylene, said heterophase propylene copolymer comprising a propylene polymer matrix and a rubber.

8. Process according to claim 7, wherein the heterophase propylene copolymer comprises a propylene polymer matrix and a rubber, said rubber comprising a first olefin, which is different from propylene, and a second olefin, which is different from the first olefin, said first olefin being present in an amount of from 2.0 wt % to 20.0 wt % relative to the total weight of the heterophase propylene copolymer.

9. Process according to claim 7, wherein the heterophase propylene copolymer is an ethylene-propylene rubber.

10. Process according to claim 7, wherein the rubber is present in an amount from 8.0 wt % to 24.0 wt % relative to the total weight of the heterophase propylene copolymer.

11. Process according to claim 7, wherein the process further comprises the step of
   (f) rapidly reducing the intermediate diameter of the fiber extruded in step (e) to a final diameter.

12. Process according to claim 7, wherein the process further comprises the steps of
   (g) collecting the fibers obtained in step (e) or step (f) on a support, and
   (h) subsequently bonding the collected fibers to form a bonded nonwoven.

13. Process according to claim 7, wherein the bonded nonwoven is a spunbond nonwoven or a spunlaced nonwoven.

* * * * *